EVALUATION OF POLLUTION OF NEWLY DEVELOPED BIODEGREDABLE FLUID DURING ACCELERATED LABORATORY TESTS

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ABSTRACT

Our study focused on evaluation of pollution from newly developed synthetic, biodegradable fluid MOL Farm UTTO Synt, produced by Slovnaft Company, member of MOL Group, Hungary. Fluid was subject of accelerated test in laboratories owned by Department of Transport and Handling, Faculty of Engineering, Slovak University of Agriculture in Nitra. Accelerated laboratory test was realized by cyclic pressure loading of hydrostatic converter. Hydrostatic pump UD 25, used in latest tractors Zetor Forterra, was selected for testing with cyclic pressure loading for the period of 106 cycles. Within selected intervals (250 000 cycles), a sample of hydraulic fluid extracted from test device was a subject of ferrographic analysis detecting a level of pollution according to ISO 4406 - Cleanliness code. Based on pollution evaluation results of newly developed fluid, considering creation of pollution particles, it is possible to monitor a process of hydrostatic pump UD 25 break-in until 500 000 cycles of pressure loading. Ferrographic analysis compared detected wear particles to particles from wear particles atlas. Only particles of adhesive wear were detected by method of comparison, which proves good operational properties of tractor hydrostatic pump with newly developed synthetic, biodegradable fluid.

Key words: accelerated laboratory test, biodegradable fluid, hydrostatic pump, pollution, ferrographic analysis, cleanliness code

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INTRODUCTION

Hydraulic equipment is widely used in powerful mechanisms of agricultural and forest machines as well as in many other areas. The development of modern hydraulic components is aimed at increasing the transmitted power, reducing the energy intensity, minimizing the environmental pollution and increasing the technical life and machine reliability (Tkáč, et al., 2010, Majdan et al., 2012). From the viewpoint of hydraulic fluid utilization in a machine, it is important to know the operating characteristics of a fluid, i. e. to know the effect of fluid on the technical condition of hydraulic system components (Tkáč, et al., 2008 ,Majdan, et al, 2010).

Over 60 % of lubricants used in the world are lost in the environment. Vegetable oils are capable to contribute to the goal of energy independence and security since they are a renewable resource (Campanella et al., 2010).

The principal aim of the tests in the laboratory conditions (rapid durability tests) is the acceleration of the wearing process for obtaining the information about the wear out of the machine during a shorter time than is the scheduled operation time of the machine (Tkáč et al., 2008a). The acceleration tests are most often realized according to the following methods (Tkáč et al. 2008b):

- by a strong dirty fluid – hydraulic fluid with a higher content of contamination has a greater influence on the durability of the hydrostatic pump,
- by increased operating pressure,
- by acceleration of the operating cycle.

MATERIAL AND METHODS

The used ecological fluid is a newly developed ecological fluid, which is made of synthetic fluid based on poly-alpha-olefins. We have chosen this fluid because it has a high chemical stability and miscibility with mineral fluids, which are currently used in tractors in Slovakia. The fluid is a new ecological fluid MOL Farm UTTO Synt produced by MOL Group, Hungary. This fluid belongs to the group of universal transmission hydraulic fluids designed for tractors. The main specifications of this fluid are listed in Table 1.

Tab. 1 Specification of New synthetic-based biodegradable fluid MOL Farm UTTO Synt

Parameter	Unit	Value
Kinematic viscosity at 100 °C	mm^2*s^{-1}	10.22
Kinematic viscosity at 40 °C	mm^2*s^{-1}	58.14
Viscosity index *VI*	-	165
Pour point	°C	-42

The tested synthetic-based fluid was used in a laboratory test device that cyclically loaded hydrostatic pump UD 25. The hydrostatic pump belongs to one-way hydrostatic pumps, which are used in the latest Zetor Forterra tractors for a common gear-hydraulic fill. The principle of test device operation is in loading of hydrostatic pump by cyclic pressure load using an electro-hydraulic control valve, which is connected to the output of the hydrostatic pump. A change in the control valve position will change the direction of fluid flow, which then flows through the pressure

relief valve into the tank or directly into the tank with fluid. These directional changes of flow result in pressure changes at the hydrostatic pump output. The hydrostatic pump is loaded with cyclic pressure load for the duration of 10^6 cycles, at rated parameters.

Cleanliness Code ISO 4406

Analysis of ecological fluid considering content of solid impurities will be realized by Hydac Contamination Sensor CS 1000 series (fig. 2). The device is based on optical detection of particles, which will results in evaluation of numbers and size of particles in detected fluid. Test devise analyses all impurity particles and separates them in individual groups considering their size 4µm, 6µm and 14µm.

Fig. 2 Wiring diagram of CS 1000 device 1-Adapter, 2-Modul of power box, 3-USB cable, 4-CS 1000 and connecting cable, 5-software pack CoCos 1000

Ferrographic analysis

The aim of ferrographic study is to identify the quantity and size of wear particles in the oil samples. We studied samples of the new oil within every 250 000 cycles. Wear particles have a significant effect on the abrasive wear of friction pairs in hydraulic circuits and on technical life of hydraulic fluid. These contaminants degrade used hydraulic oil. Particle of pollution during the test have a tendency of agglutination and aggregation into larger particles. Technological progress of ferrographic analysis was realized in the laboratory owned by Department of Transport and Handling, Faculty of Engineering, Slovak University of Agriculture in Nitra. MOL Farm UTTO Synt was diluted before ferrographic analysis in proportion of 2:1 with tetrachlorethylene for better highlight of pollution particles in the oil.

RESULT AND DISCUSSION

Pollution of hydraulic fluid and ferrographic analysis were realized within every 250 000 cycles. Measurement of pollution level according to ISO 4406-1999 requires the fluid to be warmed up to operational temperature before measurement to ensure right homogeneity.

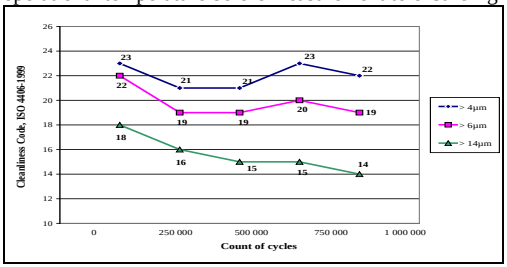

Fig. 3 Evaluation of UTTO fluid pollution according to ISO 4406

Under operation conditions, new fluid could be polluted with technology products or by incorrect storing. This fact is verified by high level of new fluid pollution. Reduction in total numbers of pollution particles (until 500 000 cycles) from values of 23/22/18 to 21/19/15 occured by reason of fluid filtration within hydraulic circuit of laboratory test device. Pollution level increased after 500 000 cycles, which might occur because of hydrostatic pump UD 25 break-in process. Creation of pollution particles decreased after 750 000 cycles, because of the end of hydrostatic pump UD 25 break-in process.

FERROGRAPHY

The evaluation was realized on sample after 250 000 cycles, when occured the fluid filtration within test device and on sample after laboratory testing. Figure 4 and 5 show wear particles, which were extracted from fluid samples (200x and 400x zoom in).

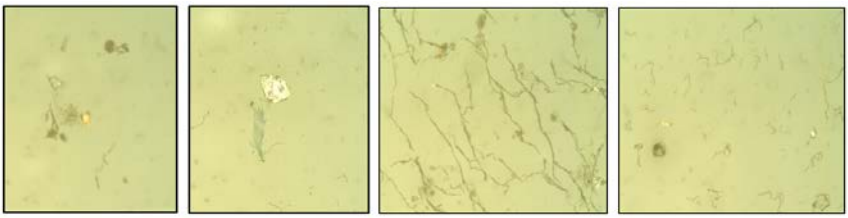

Fig. 4 Wear particles after 250 000 cycles

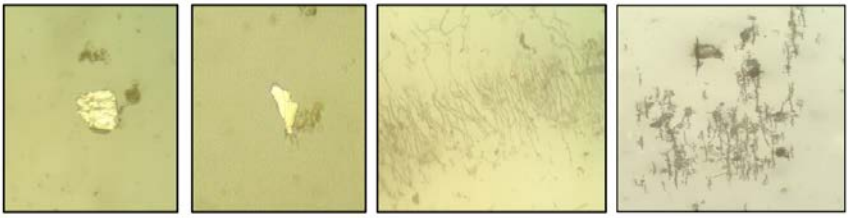

Fig. 5 Wear particles after laboratory testing

Images from ferrographic analysis indicate a presence of clusters and chains of ferromagnetic wear particles extracting from hydrostatic pump UD 25. A presence of such tiny wear particles indicates a break-in process defined by levelling of functional surfaces irregularities. Bigger wear particles also occured in fluid. Morphology of detected fluid particles was characterized by lamellar character with smooth surface, which is typical for adhesive wear particles of soft materials. By means of comparison to wear particle atlas was detected, that particles has typical character and colour of bronze particles, which is used in snap rings of hydrostatic pump UD 25.

CONCLUSIONS

The aim of the study was an evaluation of pollution from newly developed synthetic, biodegradable fluid MOL Farm UTTO Synt, which was subject of accelerated laboratory test with tractor hydrostatic pump UD 25. Results of cleanliness code indicate significant pollution of new ecological fluid before laboratory test itself. Because of that, fluid requires filtration before its operational utilization. Reduction in pollution occurred at 500 000 cycles, by reason of fluid filtration within test device. Wear particle pollution increased at 750 000 cycles, which might occur because of hydrostatic pump UD 25 break-in process. Creation of pollution particles decreased in

the end of laboratory test indicating the end of hydrostatic pump break-in process. Analyses of the ecological fluid wear particles presence was realized by ferrographic analysis. The fluid evaluation was realized after 250 000 cycles, when occured the fluid filtration and after laboratory testing. Images from ferrographic analysis show adhesive wear particles, characterized by levelling smooth surface, which indicates break-in process and begining phase of operational wear. The biggest wear particle was detected by ferrograph in fluid sample after laboratory test and the biggest extracted particle size reached a value of 42.4 μm. Based on results was detected, that hydrostatic pump with new synthetic fluid indicates good operational properties, does not excessively deteriorate technical conditions, therefore new ecological fluid is suitable alternative for conventionally produced hydraulic fluids.

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